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(57) Abstract

There is disclosed a method enabling a person to visualise images comprising the steps of: encoding spatial information relating to a feature or features contained within an image into the form of one or more musical sequences; and playing the musical sequence or sequences to the person.

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VISUALISING IMAGES

This invention relates to methods and devices enabling a person to visualise images.

The prospect of enabling subjects to visualise images through some external means, circumventing the human visual system, is one of clear significance. In particular, such a system might enable blind persons to "see", or at least assimilate some amount of visual information. Although systems based on echo location and on touch are known, there is at present no available system permitting optical images to be analysed in detail.

The system described here translates visual images into sound. However unlike any of its predecessors such as US Patent US 5 097 326 it incorporates a system for feature extraction that is designed to enable a blind subject to selectively deconstruct a complex optical image into a set of simpler representations that make it easier for the subject to analyse. Each representation selectively isolates one or more features in the visual display which is then translated into an equivalent sound pattern. The blind subject listens and analyses these representations one at a time or in combination. and uses the combination of sub- melodies to mentally reconstruct a representation of the visual target. Provision is also made to enable the subject to examine different portions of the image in a manner that bears some resemblance to the normal scan-path behaviour of the human eye, as it pursues a search pattern of foveations to explore a complex visual object (such as a face), selecting and gathering information in patch- like manner about salient features, which are then assembled to contribute collectively to the final percept and identification of the object.

US Patent US 5 097 326 discloses a system in which a visual image is pixellated and sinusoidal audio outputs are produced depending on the nature of each pixel. In this system, an audio output of characteristic frequency is associated with each pixel in a column of pixels, and the frequency of the audio output increases as one moves up a column of pixels. Furthermore, the amplitudes of each audio output from a column of Pixels are summated, and the sum is played to a listener. To the listener, this summed output can appear rather discordant. Furthermore, with complex images the output is extremely complex, making the detailed analysis of images very difficult.

It is known that there are areas of similarity in the way the human brain interprets visual and auditory information. As with vision, auditory information is partitioned into discrete packages and conveyed to the relevant brain areas for separate processing : human speech sounds such as words and phrases are processed by Wernicke's area in the left hemisphere, where music is processed in the temporal lobe of the right hemisphere. In some animals, there are areas of the brain concerned with spatial perception in which both the visual and auditory topographical maps (involved in the location of objects in the environment by vision or by hearing) are superimposed.

The approach to develop a sensory aid based on sensory substitution was guided by knowledge of the structure ands functional organization of the visual system and by neurophysiological, psychophysical and behavioral studies on visual pattern recognition in a variety of animals. For example, honeybees use a photographic memory to store and recall patterns in a (pixel by pixel fashion). However, they also distinguish patterns on the basis of global properties such as radial, circular, and bilateral symmetry. The honeybees visual system possesses spatial filters for detecting various symmetries. Radial and circular filters have also been discovered in primate vision. This suggests that information about the presence or absence of different types of symmetry in a visual target may sometimes be useful in the differentiation and characterization of visual

forms. In addition many insects that lack stereo vision use image-motion cues (differential movement parallax, changing size etc) to obtain information on depth. Image motion may also provide a powerful cue for segregating objects from their background, detecting imminent collisions, and for computing one's own motion. Likewise, the velocity flow field generated on the retina by different portions of a 3-D object as it approaches may produce sufficient information with which to reconstruct its form. These and other strategies such as visual velocity feedback for gaze and course control and the use of specialized scanning patterns for extracting information on specific visual features appear to be ubiquituous in vertebrate and invertebrate species where vision plays an important role in `directing the animal's behaviour. Consequently any system of sense substitution that aims to compensate for the loss of vision, may well require to implement a set of strategies that are functionally similar to those employed by the visual system in its analysis of the spatial and spatiotemporal features of the subjects visual environment.

The present invention is based on the surprising discovery that musical forms can be used to convey precise visual information to a subject. Such "precise" information can comprise spatial information such as the precise shapes of objects or symbols, and should be delineated from imagery which can be evoked in subjects listening to a favourite piece of music, in which instance images "brought to mind" by the music are personal in nature, and can vary quite dramatically from subject to subject. Almost certainly, this surprising discovery is related to the fundamental mechanisms governing the way in which the human brain segments, organises and processes information from various sources in multi dimensional space. However, discussion of such mechanisms is not the purpose of the present application.

According to a first aspect of the invention there is provided a method enabling a person to visualise images comprising the steps of :

encoding spatial information relating to a feature or features contained within an image into the form of one or more musical sequences; and

playing the musical sequence or sequences to the person.

Subjects appear to be particularly receptive to the use of musical notes, a phenomenon which, as discussed above, may be due to the fundamental mechanisms of information processing in the human brain.

"Spatial information" includes the shape, size, orientation and relative positions of features, as well as finer details such as surface decoration or, for example, the appearance of a face. As will be explained in more detail below, further visual information, such as colour and brightness, and temporal information, i.e. the movement of features, may also be visualised using the present invention. Features can be, for example, three dimensional objects, two dimensional objects such as drawings, or symbols such as letters, words and numbers.

Features may be encoded by selecting a note or chord dependent on the distribution of the feature or features along an axis.

The image may comprise a letter or a number, in which instance the method may be used to convey written information.

The image may comprise the person's environment, in which instance the method may be used as a way of replicating some or all of the scene that the person would view if they were sighted.

Spatial information may be encoded by:

representing the image as a two dimensional (2D) image; and

forming one or more musical sequences, each comprising a series of notes or chords, in which i) each note or chord is selected dependant upon the distribution of the feature or features along a portion of the 2D image and ii) different notes or chords in a sequence correspond to different portions of the 2D image.

The 2D image, or a portion of the 2D image, may be divided into a matrix of pixels, and i) each note or chord may be selected dependent upon the distribution of the feature or features along a column (or row) of pixels and ii) different notes or chords in a sequence may correspond to the distribution of the feature or feature along different columns (or rows) of pixels. A different note may be associated with each pixel along a column and, if a feature is recognised as being present in a pixel, the note corresponding to that pixel comprises part of the musical sequence.

The method may enable a person to visualise moving features, and may comprise the step of playing a plurality of musical sequences corresponding to different positions and/or orientations of the moving feature.

A subset of the full image may be encoded into the musical sequence or sequences. Predetermined features may be extracted from the image, and said predetermined features may be encoded into a musical sequence or sequences. In this way, and in contrast to the method of US 5 097 326, the information content of the image is reduced, and important features are highlighted. This renders the musical sequence or sequences played to the person much more tractable.

A feature may be simplified by encoding a portion of the feature as a musical sequence. The feature may be encoded by encoding different portions of the

feature as different musical sequences. This approach greatly assists in the recognition of complex shapes; such shapes can be "broken down" into simpler sub-units. For example, one deconstructed representation might select only vertical lines present in the feature, and represent them in musical form. Another musical sequence might consist only of horizontal lines present in the feature.

The image may be encoded into the form of a plurality of musical sequences which are played to the person as a melody.

The image may be encoded as a plurality of musical sequences, each corresponding to different spatial resolutions. The image may be divided into two or more concentric zones, the zone at the centre of the image being encoded at the highest spatial resolution and the zone furthest from the centre of the image being encoded at the lowest spatial resolution. A feature or features may be visualised by obtaining a plurality of images in a sequence of saccadic movements. An example is the visualisation of a face, in which features such as eyes, nose and mouth are "scanned" at high resolution in a saccadic movement which mimics the operation of the human retina.

The spatial resolution corresponding to a musical sequence may be indicated by the duration of the notes and/or chords in the sequence.

The colour of the feature or features may be encoded by producing a musical sequence or sequences which comprise a plurality of different waveforms mixed in variable ratios, the waveforms being selected so that none of the waveforms may be created by a linear combination of the other two waveforms. Three waveforms may be mixed in variable ratios. The three waveforms, may be produced by filtering a master waveform between different frequency ranges.

The brightness of the feature or features may be encoded by varying the intensity of the musical sequence or sequences.

According to a second aspect of the invention there is provided a device enabling a person to visualise images comprising:

imaging means for obtaining images of a feature or features;

encoding means for encoding spatial information relating to the feature or features according to the first aspect of the invention; and

playing means for playing the musical sequence or sequences to the person.

The imaging means may comprise at least one video camera.

The imaging means may comprise at least one charge coupled detector.

The encoding means may comprise a microprocessor.

The playing means may comprise an ear piece.

The device may be portable, in which instance the imaging means may be hand-held.

Methods and devices in accordance with the invention will now be described with reference to the accompanying drawings, in which:-

Figure 1 shows a first 2D feature;

Figure 2 shows a second 2D feature;

Figure 3 shows a sequence of locomotory motions of a bird;

Figure 4 shows the division of an image field into a number of zones of different resolution;

Figure 5 shows the coupling of different musical sequences in a melody;

Figure 6 shows a) a solid object and b)processsed to highlight the contour of the solid object by image erosion; and

Figure 7 shows a) a Necker cube, (right) a Necker cube with vertical lines removed, (b) sketches made by subject P.H., and c) sketches made by subject BK.;

Figure 8 is a schematic diagram of an apparatus to enable a person to visualise images;

Figure 9 shows recognition scores from subjects presented with complex geometrical shapes;

Figure 10 illustrates segmentation of a complex object (a house) to produce basic icons that a subject can recognise as a sequence of polyphonic melodies; and

Figure 11 shows the results from subjects presented with segmented

complex shapes.

The invention comprises a method enabling a person to visualise images comprising the steps of:

encoding spatial information relating to a feature or features contained within an image into the form of one or more musical sequences; and

playing the musical sequence or sequences to the person.

Figure 1 illustrates how the encoding may be performed on a computer generated 2D feature 10. The image 10 is, essentially, an arrangement of filled pixels which have been selected from a matrix of pixels. The musical sequence is produced by associating a different note with each pixel along a column of pixels and, if a feature is recognised as being present in a pixel, the note corresponding to that pixel comprises part of the musical sequence. If a feature occupies more than one pixel in a given column then a number of notes are played simultaneously, producing a chord. The entire image is encoded by performing this procedure for each column of pixels, thereby producing a sequence of notes or chords.

In Figure 1, this encoding procedure is performed using a moveable cursor 12. The cursor 12 is divided into 32 segments corresponding to the notes in four octaves of the scale of C major (which comprises, in ascending order, the eight notes C D E F A B C). The cursor 12 defines a Y axis. Thus, features are encoded by selecting a note or chord dependent on the distribution of the feature along the Y axis. Encoding proceeds by moving the cursor 12 along the X axis, from left to right as viewed in Figure 1. Each movement of the cursor 12 samples a new column of pixels. If the cursor 12 encounters one or more filled pixels (corresponding to a portion of the feature 10) then the note or

notes corresponding to the segments of the cursor 12 which have encountered the filled pixels are played. Thus, if the cursor 12 is moving across the screen the screen at a velocity of p columns of pixels per second, the time between the playing of successive notes or chords is 1/p seconds.

In other words, spatial information corresponding to the shape of the figure in Cartesian coordinates is encoded, or transposed, into a musical sequence in which the Y ordinate is represented by musical notes and the X ordinate by time.

Returning to the specific example shown in Figure 1, it can be seen that movement of the cursor 12 over the figure 10 will result in the playing of a musical sequence in which the ascending notes G, A, B, C of the second lowest octave and C, D, E, F of the second highest octave are played in succession.

As a further example, Figure 2 shows a computer generator square figure 20 which also comprises a number of filled pixels. When the cursor 12 is moved across the square 20, the first component of the musical sequence is a chord which comprises the ten notes A, B, C of the second lowest octave and C, D, E, F, G, A, B of the second highest octave. The number of notes involved results in a chord which gives the impression of density or thickness. The next eight components of the musical sequence are chords in which only two notes, A and B, are played, these notes corresponding to the top and bottom sides of the square 20. The result is a sound which might be described as "thinner". The final component of the musical sequence is the chord comprising the ten notes.

The use of the scale of C major (which does not contain flats or sharps) is not limiting: other musical scales may be used. Indeed, since the four octaves utilised in the above examples represents, approximately, the range of human hearing, thus

limiting the Y axis resolution of the encoded image, it may be advantageous to utilise the chromatic scale. In principle, the image might be encoded using a different coordinate system than Cartesian coordinates, such as polar coordinates.

A computer program was written in the C++ language, running under the Windows (RTM) operating system to enable 2D shapes and objects to be encoded using the approach described above. A Musical Instrument Digital Interface (MIDI) allowed interfacing to a sound card in order to play the musical sequence. Confidential tests were performed, using the software, on a number of blind subjects, and on (blind folded) sighted subjects. Extremely favourable results were obtained in tests which employed a variety of geometric shapes and letters. For example, subjects were quickly able to read simple words, having been trained on individual letters. Furthermore, subjects were able to recognise figures consisting of one geometric shape contained within another shape, (such as a triangle within a square), having been trained on the individual component geometric shapes. Figure 9 shows the recognition scores obtained to a series of geometric shapes of differing complexities.

Global perception of animal perception translated into species specific rhythmical pattern of sound

In a further development, it is possible to visualise moving features by playing a plurality of musical sequences corresponding to different positions and/or orientations of the moving feature. In this way, dynamical information can be visualised in a way which bears similarities to the principles of cinematography, in which successive frames showing different stages of the movement are shown.

The computer program described above was adapted to produce a series of images which simulate the locomotory sequence of limb movements displayed by a

variety of animal species, namely i) a galloping horse; ii) a running cheetah, iii) a walking man; iv) a flying bird; v) a swimming fish; vi) a bipedal lizard; vii) a quadrupedal lizard; viii) a wriggling worm; and ix) a crawling locust. Figure 3 shows a sequence of images containing the feature of a flying bird.

Successive musical sequences, corresponding to different "frames" in sequences of images such as that shown in Figure 3, were played to subjects in the confidential tests. Blindfolded normal and previously sighted blind subjects were able to distinguish between the different locomotory motions and, in some instances, were able to correctly identify a locomotory motion with no previous training using the locomotory motion.

Cross-modality perception of complex stationary visual images translated into sound

We now turn to the problem of encoding more complex images. The approach adopted is to substantially mimic, in a number of aspects, the operation of the human eye.

An important aspect of the present invention is the realisation that it is often advantageous to encode a subset of the full image into a musical sequence or sequences. Predetermined features can be extracted form the image, and said predetermined features may be encoded into a musical sequence or sequences. Feature extraction or pattern recognition algorithms can be used for this purpose.

For complex images it was necessary to extend the battery of search strategies available to our subjects to enable them to carry out a satisfactory exploration and analysis of the target. These included (1) a facility to mask or block out areas areas

of the image to enable the subject to carry out a patch by patch exploration and analysis of the target and to selectively examine portions of the image. This was intoduced in an attempt to simulate the tactile search pattern that a blind subject normally carries out when tactaully exploring the shape of a solid object. (2) The second major change was to carry out of a strategy of feature extraction to segment and produce a set of simplified representations of the image. In our original scheme, the entire image of the "object" was displayed on the computer screen and all pixels constituting the image were thereby primed to activate the release of the appropriate musical notes (that signalled their respective locations on the screen) when they were intercepted by the moving tracker bar. To be fully primed it was necessary and sufficient, only that a pixel be occupied by part of the image on the screen. To facilitate the analysis of more complex visual shapes we introduced several additional conditions that needed to be fulfilled before a pixel is fully primed to activate the tracker bar. Effectively this is equivalent to having the full image of the "object" appearing on the monitor screen simultaneously by several different spatially distributed sets of feature detectors that each select only those pixels included in those parts of the image that display the selected feature to which a particular array of detectors is tuned. Thus one array of orientation selective detectors may select for priming any set of pixels that lie on well defined vertical lines in the image, while another array of feature detectors may do the same for horizontal lines etc. Further provision is made to allow the subject the choice (i) of selecting which feature (or combination of features) of the image are to be presented and (ii) which "voices" are to be excluded during a particular presentation. By screening the image with several sets of detectors which select for different features (e.g. horizontal, vertical and oblique line components), we can generate musical patterns associated with an image in which all but one of the features have been removed or an image that combines simultaneously, a number of selected features (such as vertical and horizontal line components, or for sounding the whole figure i.e. by priming all the pixels and by arranging to scan and sound all the "voices" (segmented parts of the melody) simultaneously. Effectively this

allows the subject to isolate and separately examine the contents of several segmented packages in which different features of the image have been sequestered.

Feature Extraction and Image Simplification

In the case of complex images, it is often confusing to a listener if the full image is encoded, because the associated musical sequence is too complex. By encoding only certain features, it becomes easier for a subject to distinguish, or resolve, identifiable features. There are a numbers of ways in which the encoded information might be presented to a listener. One way is to play a single, simplified musical sequence to the person. Alternatively, numerous musical sequences might be played: there are a number of ways in which a plurality of musical sequences can be presented to a person, and these are discussed below.

Individual features present in an image can themselves be of complicated shape and form. A feature can be simplified by encoding a portion of the feature as a musical sequence.

Eroding the Image to Sharpen and Extract Object Contents

One example of this is if a feature is a solid object, such as the object 60 shown in Figure 6a. Encoding the entire object 60 into a musical sequence would result in a long series of chords each containing multiple notes. It is difficult for a subject to distinguish finer details of the scope of the object 60 from such a musical sequence. It is advantageous to encode only the edges of the object 60 as a musical sequence, resulting in a sequence which is more tractable to the subject. This can be achieved by pre-processing the object 60 to produce an outline object 62 (Figure 6b). The outline object 62 is then encoded.

Another example of feature simplification is provided by encoding different portions of a feature as different musical sequences. The different portions can comprise, for example, vertical lines, horizontal lines or sloping lines present in the feature.

Example

Figure 7 shows a Necker cube 70, which is a two dimensional representation of a wire model of a cube. In confidential tests, subjects were presented with the musical sequence associated with the Necker cube. Before the presentation each subject told that the feature was a 2-D representation of a 3-D wire model of some object, and they were required to analyse the sound pattern, and from this, to reconstruct its form. A sighted subject PH was given a drawing pad and invited to sketch the shapes he inferred from listening to the sound pattern during the process of reconstruction (see Figure 7b). A blind subject BK was reluctant on this occasion to attempt any drawing while performing the task but did produce one later when asked how he had analysed the shape.

Test procedure for PH. (i) Subject was allowed to listen to a series of presentations of the whole Necker cube figure 70. He reported that the task was "difficult". (ii) Experimenter suggests he simplify the figure and did so by removing the vertical struts and presenting the subject with the two rhomboid surfaces 72, 74 depicted in Figure 7a (right). After listening to a number of presentations of the deconstructed figure the subject asked for the original whole figure to be played back to him. PH then produced a series of sketches in which he reconstructed the Necker cube.

Test procedure for BK. The subject was given the same instructions as PH except that on this occasion, BK chose not to draw but to analyse and reconstruct it mentally and give a verbal description. After listening to several (sound) presentations

of the entire Necker cube figure, and without it being segmented or disassembled, BK declared that he was able to analyse the basic line elements and their spatial arrangement relative to one another, whereupon he identified the figure as a "cube". When asked later to illustrate how he had done this he produced the set of drawings depicted in Figure 7c.

The amount of feature simplification can be varied as a user learns to recognise more complicated structures. Thus, once a user has learnt to recognise these, they can be used by the subject as building blocks with which to analyse more complex figures. A user might learn to recognise a feature by listening to a portion of the feature, and then returning to the musical sequence corresponding to the entire feature, such as described in the Example. Alternatively, the entire feature might be encoded by encoding different portions of the feature as different musical sequences. In a trivial example, a square might be encoded by forming one musical sequence corresponding to the two vertical lines of the square, and forming another musical sequence corresponding to the two horizontal lines. The two musical sequences might be played to a subject in series, i.e., sequentially, or, more subtly, in parallel.

Representing and processing images to different levels of resolution

Figure 4 shows how an image might be divided into a number of concentric domains or zones 40, 42, 44, 46, for the purpose of encoding an image. The spatial resolution, i.e. the size of the pixels used to produce a musical sequence, is different in each zone 40, 42, 44, 46. More specifically, the image defined by the largest zone 40 is encoded at the lowest resolution, zone 42 corresponds to a medium resolution, zone 44 corresponds to a medium/high resolution, whilst the image defined by the smallest zone 46 is encoded at the highest resolution. The use of four zones in this way is similar to the structural divisions of the fundus of the human eye, in which visual activity is highest at the foveola, in the centre of the retina, and diminishes going radially from the centre

of the retina, through the foveola, fovea, parafovea and perifovea. The use of four concentric zones is not limiting : different numbers of zones might be employed. In principle, the zones need not be concentric, although, for reasons outlined below, this configuration is strongly preferred.

This constitutes preprocessing which utilizes a selective process of feature extracting modules to first deconstruct the image into separate packages; then convert them into equivalent musical phrases and presents these to the subject as the several "voices of a polyphonic melody", and is an extremely important tool for analysing the structure of complex images.

Basic icons extracted can be used in the analysis of simple shapes

The visual system of mammals and primates, contains neurons sensitive to line orientation that are an important subset of the feature selective elements in the brain that play a key role in the analysis and perceptual representation of visual forms. In the immature brain they and other feature detectors, may represent the functional building blocks (basic icons) for the later assembly, through learning, of more elaborate and sophisticated feature detectors (learned icons), that preprocess visual information in parallel and are used by the experienced adult brain, to speed up analysis and perception of the visual world. Following this line of reasoning we supplied our subjects (blind, and normal (blindfolded) alike) with a verbal description of the musical equivalent of a set of basic line elements which they were instructed to utilise to analyse the characteristic sound signatures generated by different shapes and to use this information to reconstruct the visual form. They were also encouraged to explore the figure for symmetrical features that may help them in the task of visual contour identification.

It will be apparent that it is possible to observe a scene at low resolution,

and then to pan it so that individual features can be resolved at higher resolution receptive fields. Furthermore, the configuration of Figure 4 might be used to view a scene or object in saccadic fashion. Saccadic eye movements are rapid, ballistic movements of the eyes used in scanning a scene or object. They are used to locate the portion of the image of interest onto the fovea i.e. the zone of the retina with the finest granularity and resolution. An example is facial recognition in which the eye motion rapidly and successively puts features such as eyes, nose and mouth in the central, high resolution foveola and fovea zones of the retina. Due to time taken in playing a musical sequence, such saccadic movements using the present invention will be less rapid than in the human eye. However, it is quite feasible that a low resolution image, encoded using the present invention, might be used to indicate features of interest which are successively brought into the central portion of the image for visualisation at high resolution.

From the foregoing, it will be apparent that image or images can be segregated into a plurality of musical sequences, corresponding, for example, views at different resolutions, saccadic compilations of several related images, and "special" sequences relating to certain "programmed" features. These separate auditory representations may be bound into a single percept by the use of melody. Consider an example in which the outline of a house is presented on one sequence, followed by the finer details of features (Figure 10).

The image of the house would then be encoded in a (repeated) musical melody in which the outline of the house featured as the contents of one window, and other features etc contained in the other.

To generate the "melody" (which encompasses the contents of both windows) and to preserve a sense of the "spatial" relationships between them we

introduce two additional modifications:

(i) Figure 5a illustrates how to alternate the presentations by modulating the sound intensity of each window presentation 50, 52 above and below the auditory threshold and arranging for the intensity modulation of the two presentations 50, 52 to be 180 degrees out of phase.

(ii) Figure 5b shows the continued modulation of the sound intensity of presentation 50, symmetrically about the auditory threshold. For the other presentation 52 we shift the baseline of its modulation a fraction up, so that it lies some distance above the auditory threshold. Thus we have introduced:

(a) a tempo which musically brackets the contents of the two windows within the simple melody

(b) a short interval at the start and end of each cycle when a portion of each window may be heard simultaneously - one rising in intensity, the other decreasing.

Thus by simply shifting the modulation baseline of one or the other above or below the auditory threshold one may selectively present and listen to:

(i) the contents of one of the "voices".

(ii) generate a full alternation of the contents of each window.

(iii) a tempo that brackets the contents of the two windows: allowing the observer to perceive them as a single entity (much as the theme tune of a song).

(iv) portions of both windows simultaneously.

Figure 11 illustrates the responses to such an approach by subjects tested on segmented complex images (a boat, a staircase, a house, a castle).

The confidential experiments demonstrate that blind (previously sighted but lacking light perception) and blindfolded(normal) subjects can utilise the sound representations of visual images to analyse the structure of novel (and relatively complex) visual forms. They achieve this by deconstructing the figure into its constituent line elements and from there proceed to a fairly accurate reconstruction and description of the whole figure. Whilst in some instances they failed to correctly name the object, they were nevertheless still able to produce an accurate description or sketch of the figure presented to them (e.g. the house and castle in Figure 11). This shows that we were not simply providing the subject with a dictionary of complex sounds that are associated with specific objects but are providing them with the tools with which to analyse novel complex objects in terms of simpler building blocks (e.g. basic line elements) whose associated sound signatures they had either learned previously or appeared to recognise naturally (Figures 1,2). Once subjects have successfully carried out an analysis and identified a visual form we find they progress to being able to recognise and isolate more complex features of the object which they subsequently use as higher level cues (new feature detectors that are established through learning) to facilitate recognition on subsequent presentations of the object (and in some cases becoming a high level feature detector whose selectivity is for the object itself). Whatever the sensory modality, the use of feature detectors to segment a complex stimulus pattern, seems to be the key to analysing (and reconstructing) novel complex shapes.

This approach can be extended using principles well established in

musicology in order to generate and modulate complex melodies with many subsidiary "voices". Each "voice" contains visual information, and furthermore, visual information can be contained in the relationships between the "voices". The individual musical sequences might utilise different waveforms, i.e. different instruments or different voices might be allocated to different musical sequences, giving rise to considerations of harmony.

The colour of features can be represented using the present invention. In classical colour theory, the perception of colour is generated through the differential absorption of different wavebands of light by the visual pigments contained in 3 types of photoreceptor which serve as primaries. Any 3 coloured lights can serve as primaries provided only that when mixed together in suitable proportions they produced the sensation of "white" and perhaps more importantly: on condition that it should not be possible to match one of those by linear combination of the other two.

One way of achieving such colour mixing with the present invention is to select a master waveform corresponding to a musical instrument which spans a reasonable range of octaves and whose notes contain a rich range of harmonic overtones. A triad of primary waveforms, for every notes in the span of octaves employed in the musical sequences, is generated as follows:

(i) To generate the "long wavelength" version of that note we use a sound bandpass filter to remove some of the medium and higher frequency components from the sound normally generated by that note.

(ii) For the "medium wavelength" version of the same note we follow

the same procedure except that we filter out some of the high and low frequency components.

(iii) For the "short wavelength" version we filter out some of the low and medium frequency components.

(iv) Next we adjust the relative intensities of the triad generated so that when they are sounded together they retrieve the sound generated by the original note (which serves as the achromatic note in the set).

(v) This triad should satisfy the principal condition required of a set of colour primaries: namely that it should not be possible for the sound of any one of the triad to be matched by a suitable (intensity) mixture of the other two.

The procedure described above is repeated for each note in the entire set of octaves utilised by the present invention. However to obtain a suitable set of triads for each note, the characteristics of the bandpass filters need to be altered in each case to take account of the change in pitch of the zero harmonic (fundamental) as we progress up or down the scale of notes.

An alternative method – the method of choice – is to employ three different musical instruments that differ in the sounds produced but having the same fundamental frequency encoding pixel position. Colour coding may be achieved by mixing the three harmonic sets in desired proportions. Thus a point can be represented both by the position and by colour together.

Spatial characteristics of visual displays

The system may also be used to translate image motion cues (such as differential movement, parallax, changing size) into equivalent sound patterns which can be utilised to segregate figure from background in 3D and produce information on the relative depth between visual objects.

The present invention provides devices enabling a person to visualise images. Such devices comprise: imaging means for obtaining images of a feature or features; encoding means for encoding spatial information relating to the feature or features in the manner described above; and playing means for playing the musical sequence or sequences to the person.

The imaging means can comprise a video camera, although other means, such as CCD or photovoltaic detectors, might be employed. The encoding means performs the functions of analysing the image produced by the imaging means in a suitable manner, and encoding the analysed image into suitable musical sequences. The analysis step might comprise the division of the image, or portions of the image, into the desired number of pixels. It is of course highly desirable that the device is portable, and thus a small, dedicated microprocessor might be used as encoding means. A small video camera can be used as part of a portable device: the video camera can be incorporated into a hand-held "wand. In both instances, scanning movements can be accomplished by the person via hand motion or automatically. The playing means can comprise an ear-piece worn by the person.

Figure 8 shows a system comprising a CCD camera 80 which captures images and relays the data to a personal computer (PC) 82. The PC 82 is adapted, through the use of suitable software, to perform certain preprocessing of the data and to generate, in real time, appropriate musical sequences using the MIDI protocol. The PC 82 is interfaced to a sound card (not shown) which permits musical sequences to be

played on a loudspeaker 84.

Preprocessing of the image captured by the camera 80 proceeds according to the following scheme:

1. The image is positioned on a grid comprising a plurality of pixels. The pixel size is variable, thereby permitting variation of the spatial resolution.

2. The image is thresholded, so that each pixel in the grid is either black or white. Selection of achromatic pixel colour (black or white) is dependent on whether intensity of the image within the pixel exceeds a predetermined threshold.

3. The edges of the features present in the image are detected. Various filters for these purposes are know in the art: in this embodiment, a Sobel filter or a Laplace filter can be used.

4. "Erosion" of solid objects is performed to produce an outline object of the type described previously in relation to Figure 6b. The resulting outline object consists only of edges: this processing simplifies the musical sequence associated with the image, and improves subsequent shape or feature recognition steps.

5. Musical notes are assigned in order to encode the image. This is achieved by using a net of relatively large "grid elements" in which each grid element contains a number of pixels. The average intensity of the pixels in a grid element is calculated, and a note is

assigned to the grid element only if a predetermined intensity threshold is exceeded. This process reduces the spatial resolution of the encoded images, but, very usefully, reduces the effect of noise in the image. In this non-limiting embodiment, a total of 53 white scale notes are employed, i.e., the Y axis of the encoded image comprises 53 sub-divisions.

The software offers numerous additional facilities. Shape recognition algorithms can be selected to recognise, for example, edges, corners, circles, straight lines etc. Boolean logic operators AND and OR can be employed to compare consecutive images, either before or after preprocessing. This is useful inter alia for detecting movement of objects.

Due to the digital nature of the data, it is possible to zoom in and out of the image using the software.

It would be possible to produce a portable version of this system by replacing the PC 82 with a compact unit comprising a dedicated microprocessor. Musical sequences can be played to a user with an ear piece.

CLAIMS

1. A method enabling a person to visualise images comprising the steps of:

encoding spatial information relating to a feature or features contained within an image into the form of one or more musical sequences; and.

playing the musical sequence or sequences to the person.

2. A method according to claim 1 in which spatial information is encoded by selecting a note or chord dependent on the distribution of the feature or features along an axis.

3. A method according to claim 1 or claim 2 in which the image comprises a letter or a number.

4. A method according to any of claims 1 to 3 in which the image comprises the person's environment.

5. A method according to any of the previous claim in which spatial information is encoded by:

represent the image as a 2D image

forming one or more musical sequences, each comprising a series of notes or chords, in which i) each note or chord is selected dependent upon the distribution of the feature or features along a portion of the 2D image and ii) different notes or chords in a sequence correspond to different portions

of the 2D image.

6. A method according to claim 5 in which the 2D image, or a portion of the 2D image, is divided into a matrix of pixels, and i) each note or chord is selected dependent upon the distribution of the feature or features along a column (or rows) of pixels and ii) different notes or chords in a sequence correspond to the distribution of the feature or features along different columns (or rows) of pixels.

7. A method according t o claim 6 in which a different note is associated with each pixel along a column and, if a feature recognised as being present in a pixel, the note corresponding to that pixel comprises part of the musical sequence.

8. A method according to any of claims 1 to 7 enabling a person to visualise moving features comprising the step of playing a plurality of musical sequences corresponding to different positions and/or orientations of the moving feature.

9. A method according to any previous claims in which a subset of the full image is encoded into the musical sequence or sequences.

10. A method according to claim 9 in which predetermined features are extracted from the image, and said predetermined features are encoded into a musical sequence or sequences.

11. A method according to any previous claims in which a feature is simplified by encoding a portion of the feature as a musical sequence.

12. A method according to claim 11 in which the feature is encoded by encoding different portions of the feature as different musical sequences.

13. A method according to any of the previous claims in which the image is encoded into the form of a plurality of musical sequences which are played to the person as a melody.

14. A method according to any of the previous claims in which the image is encoded as a plurality of musical sequences, each corresponding to different spatial resolutions.

15. A method according to claim 14 in which the image is divided into two or more concentric zones, the zone at the centre of the image being optionally encoded at the highest spatial resolution and the zone furthest from the centre of the image being encoded at the lowest spatial resolution.

16. A method according to claim 15 in which a feature or features are visualised by obtaining a plurality of images in a saccadic-like series of movements, functionally equivalent to a scan path that the eye follows when it examines an object.

17. A method according to any of claims 14 to 16 in which the spatial resolution corresponding to a musical sequence is indicated by the duration of the notes and chords in the sequence.

18. A method according to any of the previous claims in which the colour of the feature or features is encoded by producing a musical sequence or sequences which comprise a plurality of different sets of waveforms corresponding to the harmonics of different sound instruments mixed in variable ratios.

19. A method according to claim 18 in which three waveforms are mixed in variable ratios.

20. A method according to claim 19 in which the three waveforms are produced by filtering a master waveform between different frequency ranges.

21. A method according to any of the previous claims in which the brightness of the feature or features is encoded by varying the intensity of the musical sequence or sequences.

22. A method according to any previous claims in which image motion cues are translated into equivalent sound patterns which are utilised to segregate foreground features from background in 3D and produce information on the relative depth between features.

23. A device enabling a person to visualise images comprising:

imaging means for obtaining images of a feature or features;

encoding means for encoding spatial information relating to the feature or features according to any of claims 1 to 22; and

playing means for playing the musical sequence or sequences to the person.

24. A device according to claim 23 in which the imaging means comprises at least one video camera.

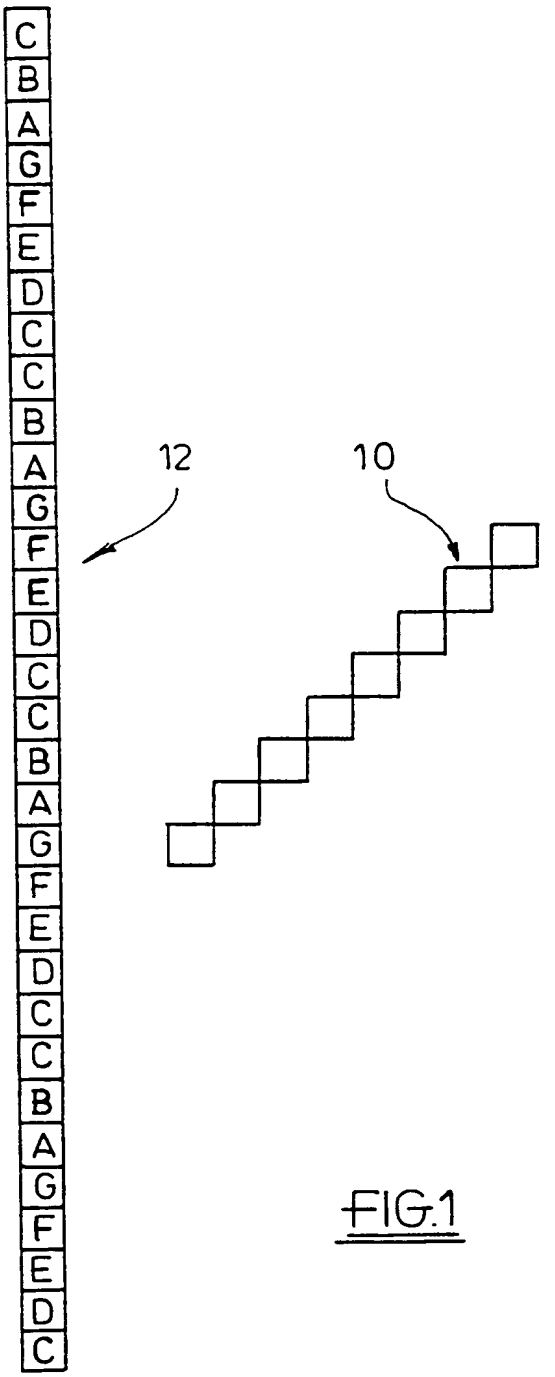
25. A device according to claim 23 in which the imaging means comprises at

least one charge coupled detector.

26. A device according to any of claims 23 to 25 in which the encoding means comprises a microprocessor.

27. A device according to any of claims 23 to 26 in which the playing means comprises an ear-piece.

28. A portable device according to any of claims 23 to 27 in which the imaging means is hand-held.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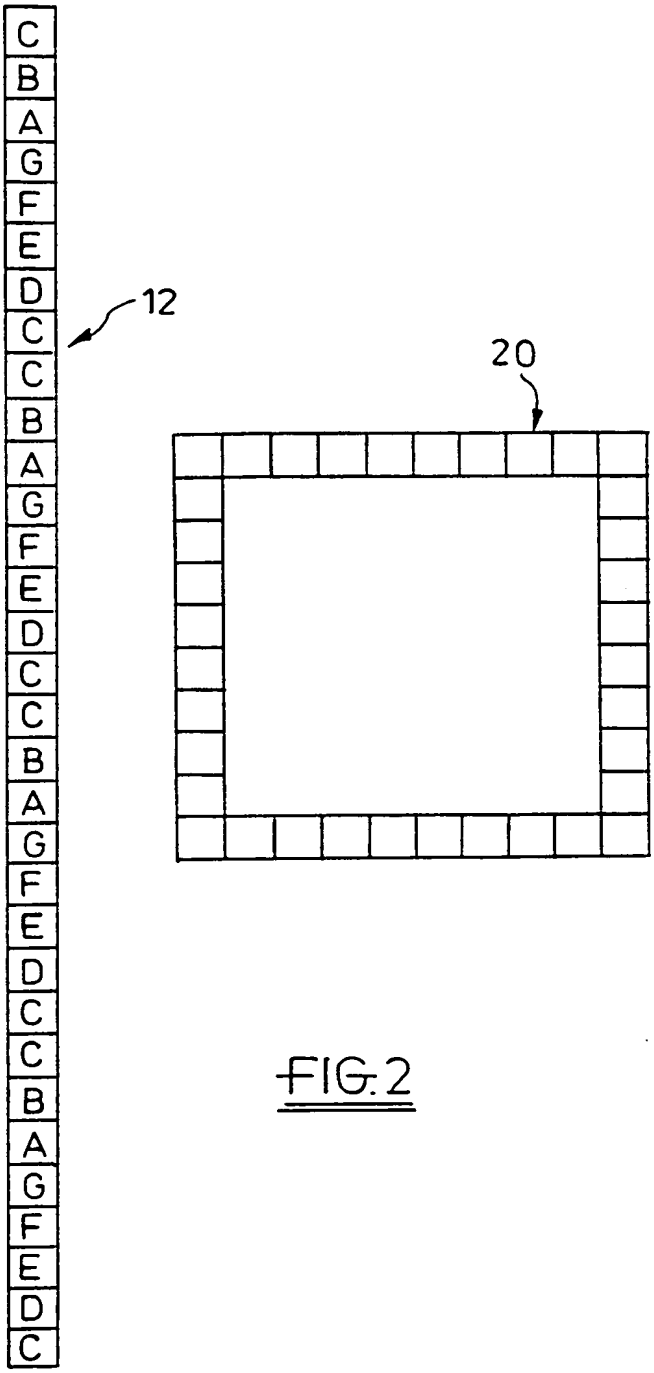
E
D
C
12
10

FIG.1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D
C
12
20

FIG.2

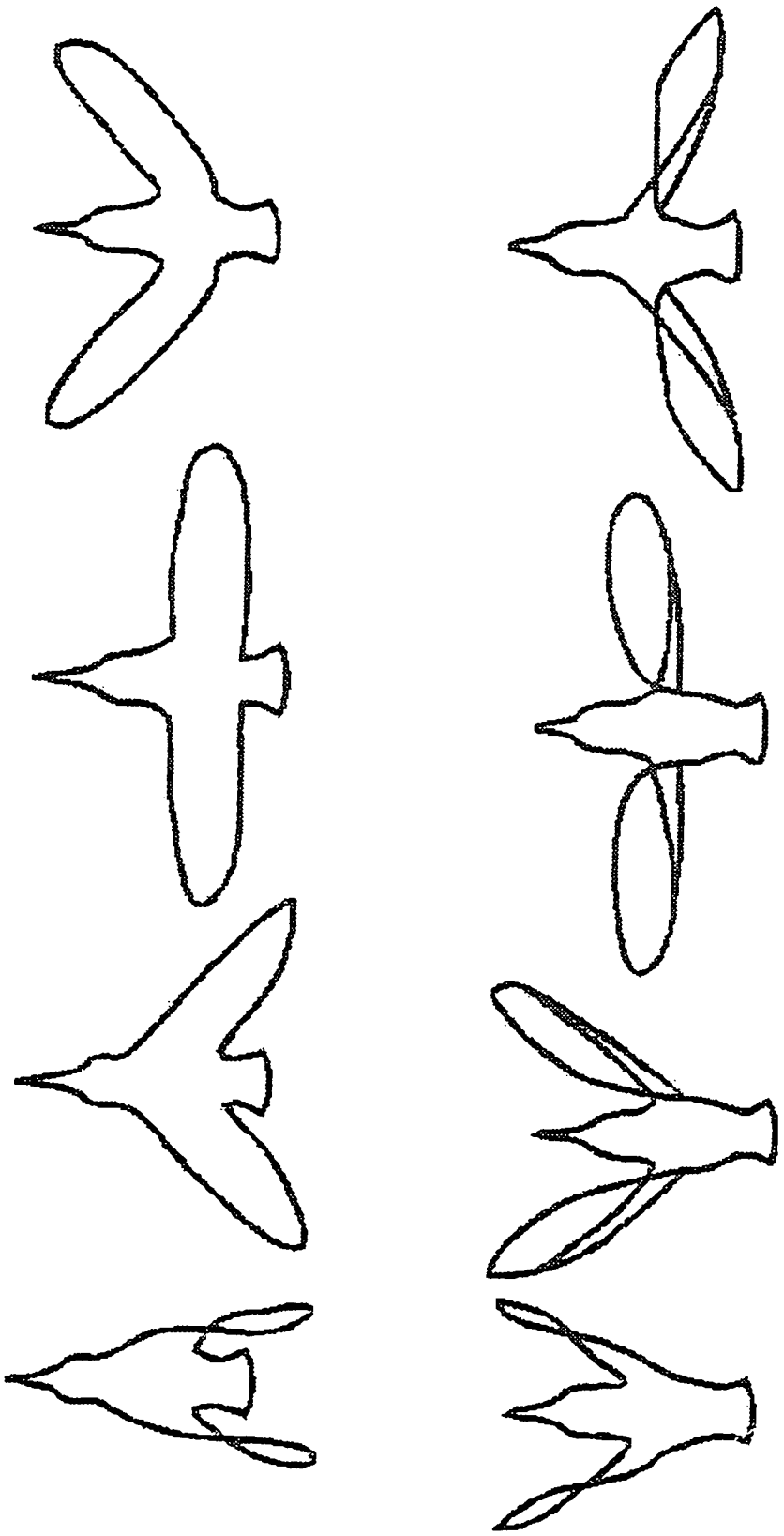


FIG. 3

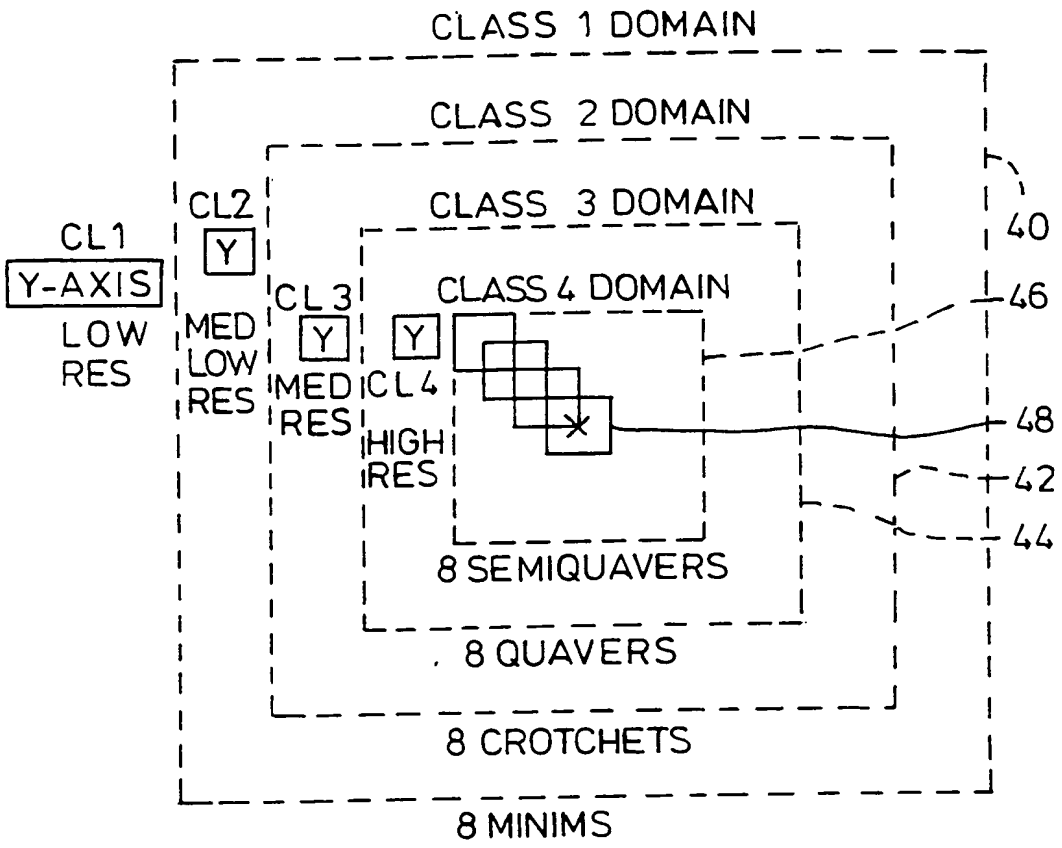

CLASS 1 DOMAIN
CLASS 2 DOMAIN
CLASS 3 DOMAIN
CLASS 4 DOMAIN
CL1
Y-AXIS
LOW RES
CL2
Y
MED LOW RES
CL3
Y
MED RES
Y
CL4
HIGH RES
40
46
48
42
44
8 SEMIQUAVERS
8 QUAVERS
8 CROTCHETS
8 MINIMS

FIG.4

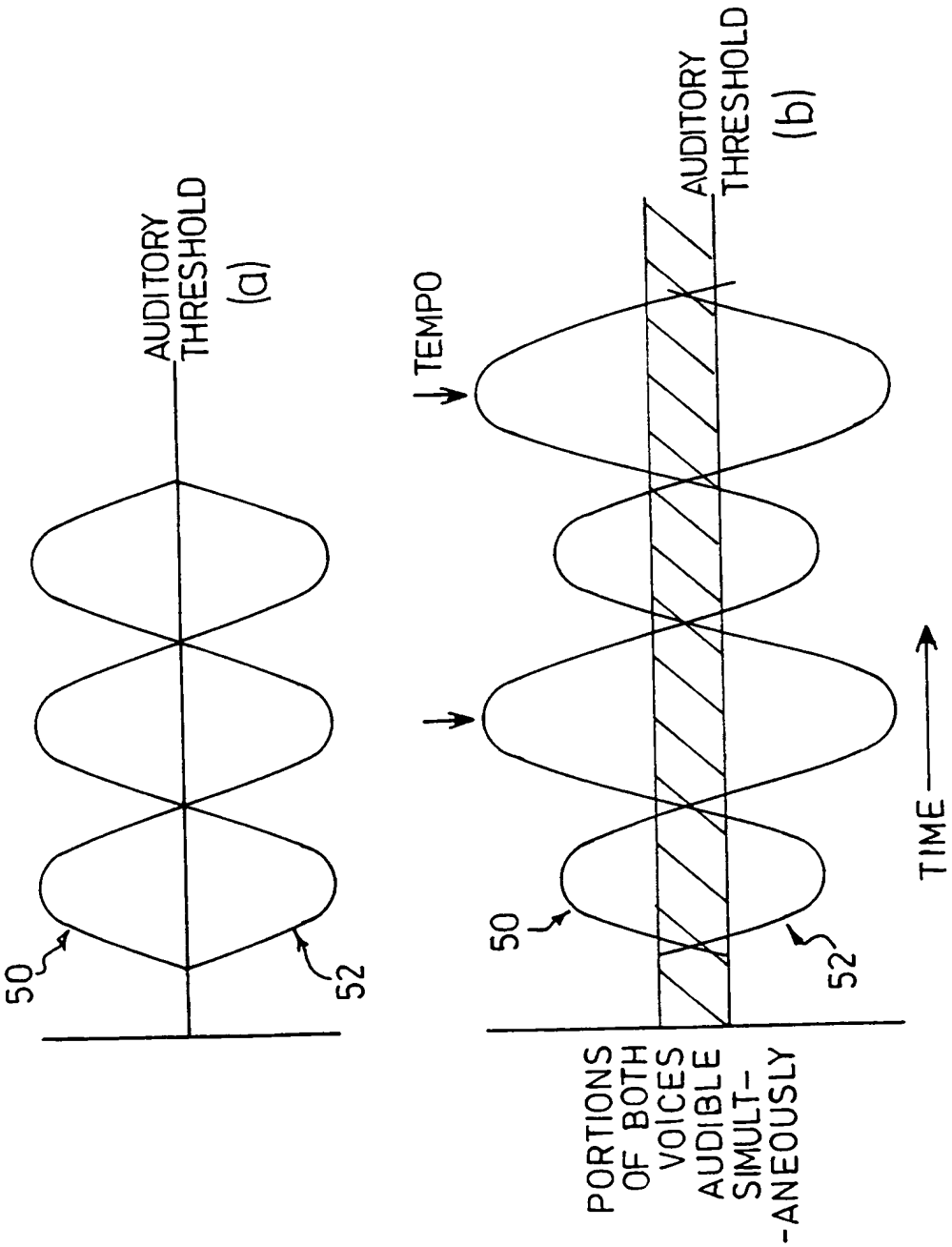

AUDITORY THRESHOLD
(a)
50
52
TEMPO
AUDITORY THRESHOLD
(b)
50
52
TIME
PORTIONS OF BOTH VOICES AUDIBLE SIMULT-ANEOUSLY

FIG. 5

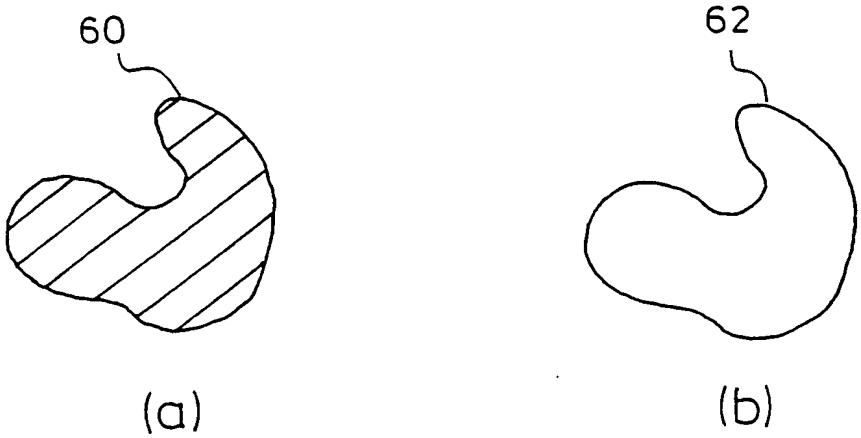


FIG.6

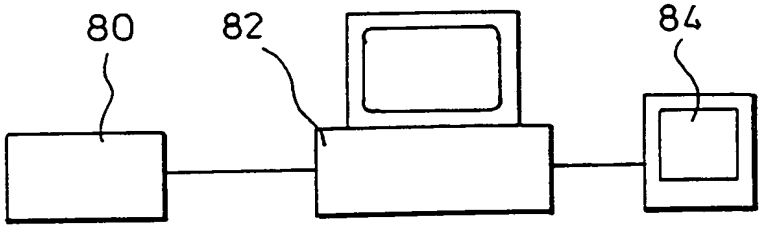
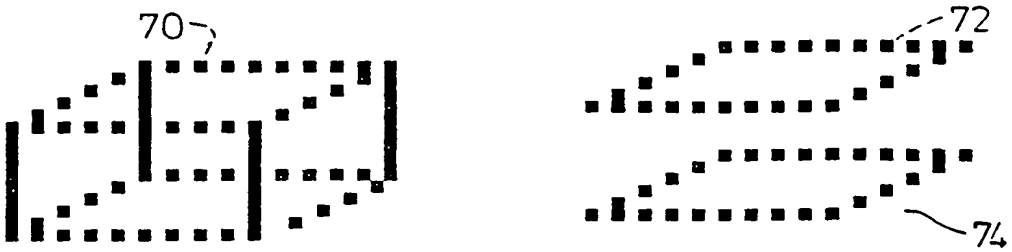
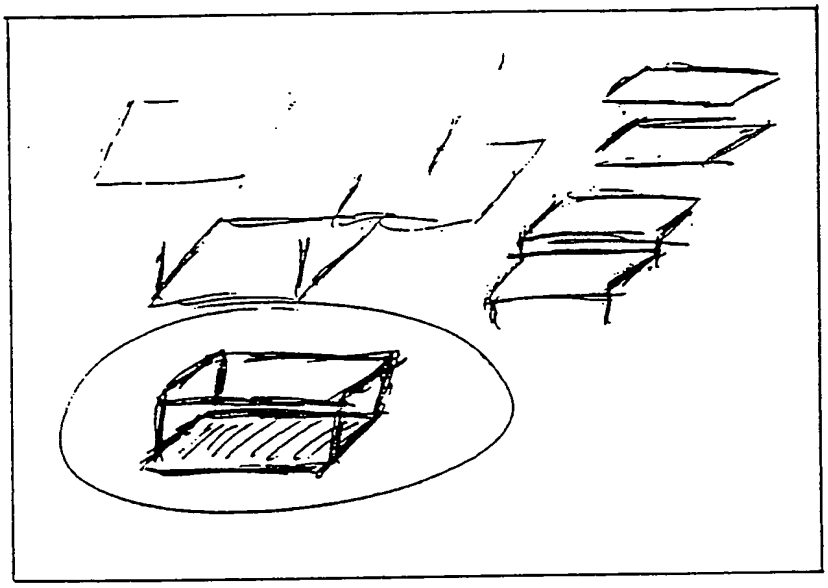


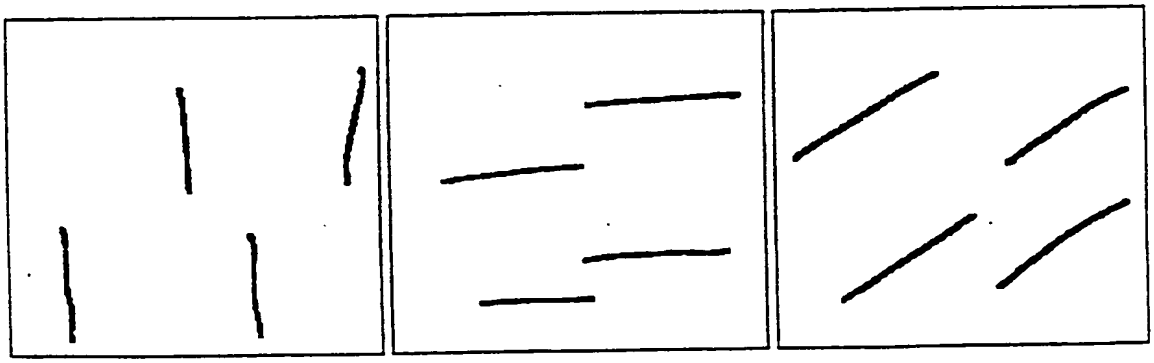
FIG. 8



(a)



(a) P.H. (NORMAL SUBJECT)



(c) B.K. (BLIND SUBJECT)

FIG.7

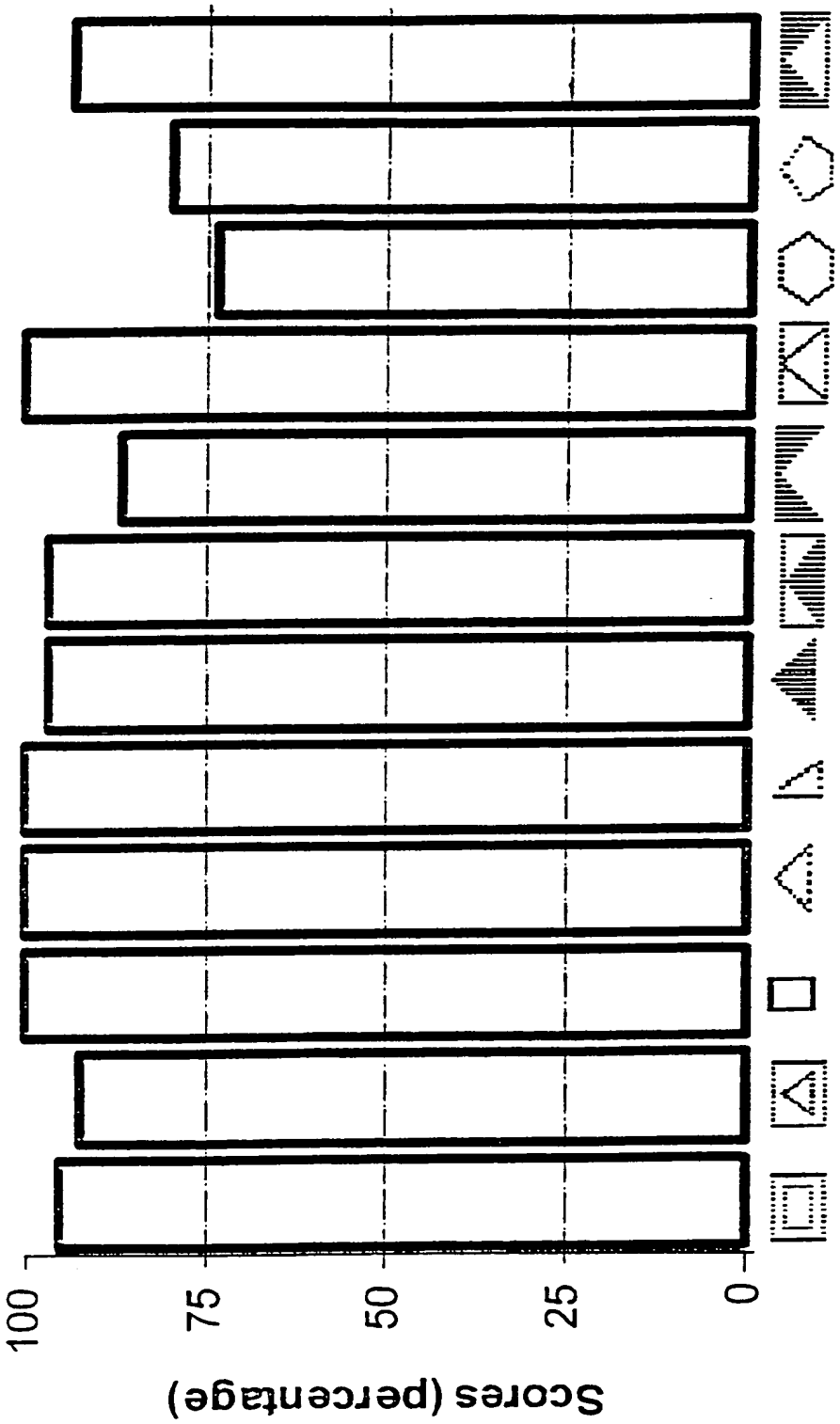


FIG.9

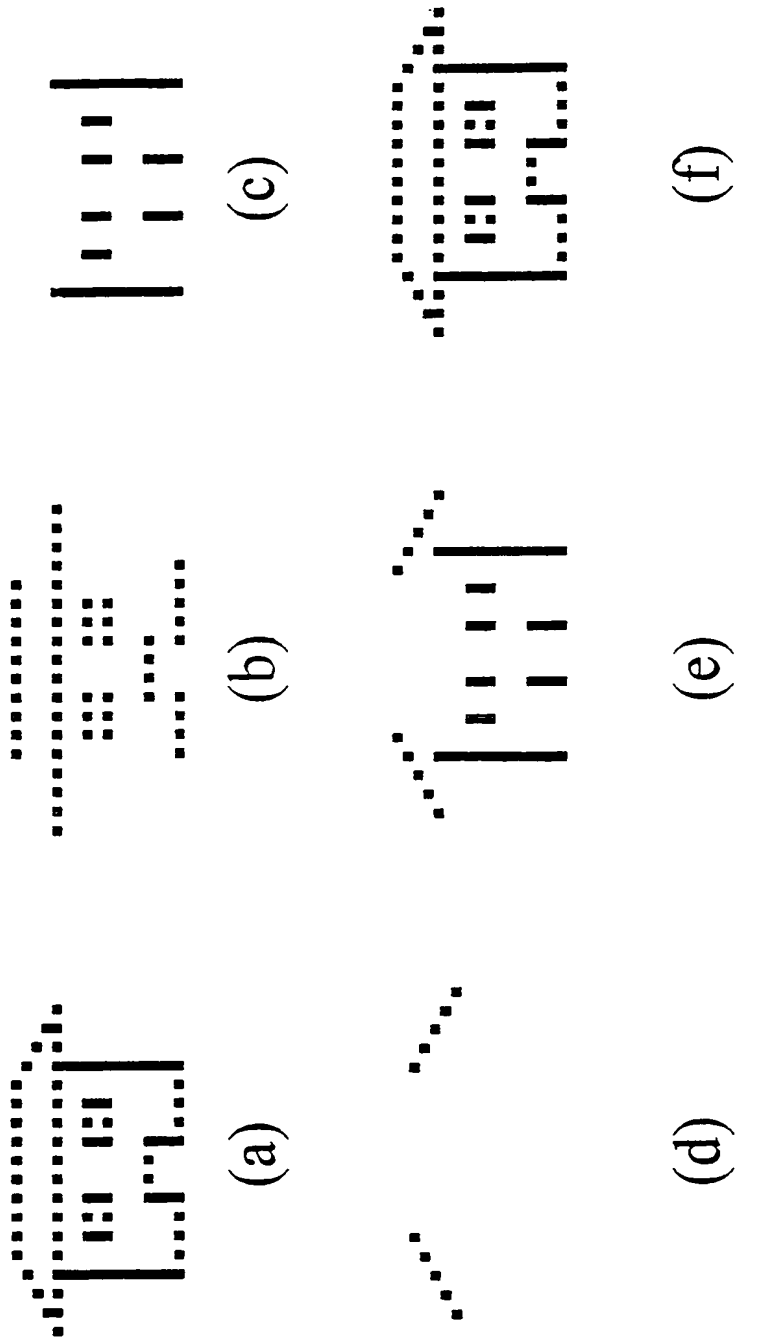


FIG.10

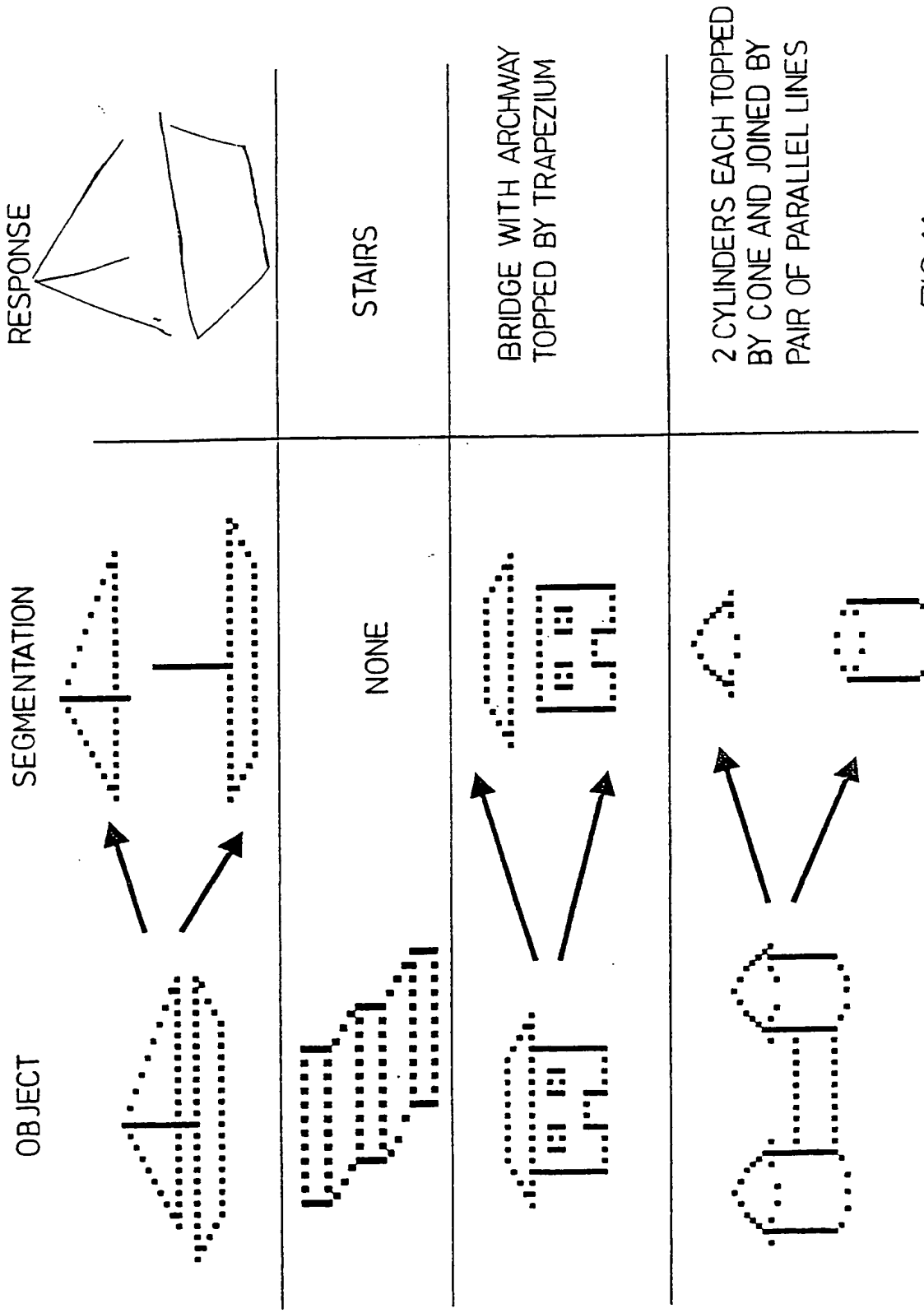

RESPONSE
STAIRS
BRIDGE WITH ARCHWAY TOPPED BY TRAPEZIUM
2 CYLINDERS EACH TOPPED BY CONE AND JOINED BY PAIR OF PARALLEL LINES
SEGMENTATION
NONE
OBJECT

FIG.11

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A3

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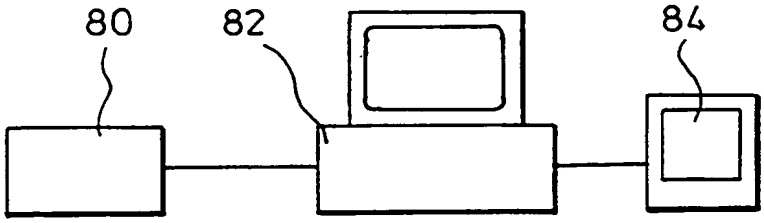

(57) Abstract

There is disclosed a method enabling a person to visualise images comprising the steps of: encoding spatial information relating to a feature or features contained within an image into the form of one or more musical sequences; and playing the musical sequence or sequences to the person.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/GB 99/01506

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: A61F 9/08, H04N 7/18
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: A61F, H04N, G09B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPODOC, WPIL

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 8200395 A1 (THALES RESOURCES, INC.), 4 February 1982 (04.02.82), the whole document	1-13,21, 23-25,27
Y		14,15,26,28
	--	
Y	BE 1003022 A3 (UNIVERSITE CATHOLIQUE DE LOUVAIN), 29 October 1991 (29.10.91), the whole document	14,15,26,28
	--	
A	EP 0410045 A1 (N.V. PHILIPS' GLOEILAMPENFABRIEKEN), 30 January 1991 (30.01.91), figure 2, abstract	1-21,23-28
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[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/GB 99/01506

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5310962 A (M. KIMPARA ET AL), 10 May 1994 (10.05.94), figure 5, abstract --	1-21,23-28
A	US 4322744 A (A.N. STANTON), 30 March 1982 (30.03.82), figure 8, abstract --	1-21,23-28
A	US 4000565 A (A.W. OVERBY ET AL), 4 January 1977 (04.01.77), abstract --	1-21,23-28
A	FR 2596940 A1 (P. DE TIEGE), 9 October 1987 (09.10.87), figure 1, abstract -- --------	1-21,23-28

INTERNATIONAL SEARCH REPORT

International application No.
PCT/GB 99/ 01506

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 22
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
The matter claimed in claim 22 is not clear. See articles 5 and 6.

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

28/09/99

International application No.
PCT/GB 99/01506

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 8200395 A1	04/02/82	AT 18841 T	15/04/86
		AU 546019 B	08/08/85
		AU 7376881 A	16/02/82
		CA 1165447 A	10/04/84
		EP 0055762 A,B	14/07/82
		US 4378569 A	29/03/83
BE 1003022 A3	29/10/91	NONE	
EP 0410045 A1	30/01/91	JP 3184540 A	12/08/91
		US 5097326 A	17/03/92
US 5310962 A	10/05/94	JP 63309499 A	16/12/88
		US 5159140 A	27/10/92
		JP 1070797 A	16/03/89
		JP 2086674 C	02/09/96
		JP 8003715 B	17/01/96
		JP 1091189 A	10/04/89
		JP 2629740 B	16/07/97
		JP 1091190 A	10/04/89
		JP 1091188 A	10/04/89
		JP 2508136 B	19/06/96
		US 4913297 A	03/04/90
US 4322744 A	30/03/82	NONE	
US 4000565 A	04/01/77	NONE	
FR 2596940 A1	09/10/87	NONE	

09/700 087
2674

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
M98/0209/PCT		

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/GB99/01506	12/05/1999	12/05/1998

International Patent Classification (IPC) or national classification and IPC
A61F9/08

Applicant
UNIVERSITY OF MANCHESTER INST....TECHNOLOGYetal.

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 8 sheets, including this cover sheet.

☐ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of sheets.

3. This report contains indications relating to the following items:

- I ☒ Basis of the report
- II ☐ Priority
- III ☒ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
- VI ☐ Certain documents cited
- VII ☒ Certain defects in the international application
- VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
08/12/1999	08.09.2000

Name and mailing address of the international preliminary examining authority:

European Patent Office
D-80298 Munich
Tel. +49 89 2399 - 0 Tx: 523656 epmu d
Fax: +49 89 2399 - 4465

Authorized officer

Krantz, L

Telephone No. +49 89 2399 2523

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB99/01506

I. Basis of the report

1. This report has been drawn on the basis of (*substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments.*):

Description, pages:

1-25 as originally filed

Claims, No.:

1-28 as originally filed

Drawings, sheets:

1/9-9/9 as originally filed

2. The amendments have resulted in the cancellation of:

☐ the description, pages:
☐ the claims, Nos.:
☐ the drawings, sheets:

3. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

4. Additional observations, if necessary:

III. Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non-obvious), or to be industrially applicable have not been examined in respect of:

☐ the entire international application.

☒ claims Nos. 1 - 22.

because:

☒ the said international application, or the said claims Nos. 1 - 21 relate to the following subject matter which does not require an international preliminary examination (*specify*):

see separate sheet

☐ the description, claims or drawings (*indicate particular elements below*) or said claims Nos. are so unclear that no meaningful opinion could be formed (*specify*):

☐ the claims, or said claims Nos. are so inadequately supported by the description that no meaningful opinion could be formed.

☒ no international search report has been established for the said claims Nos. 22 .

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims 27
	No:	Claims 23 - 26 , 28
Inventive step (IS)	Yes:	Claims
	No:	Claims 27
Industrial applicability (IA)	Yes:	Claims
	No:	Claims 1 - 21

2. Citations and explanations

see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

see separate sheet

The following documents cited in the International Search report will be referred to by means of the following appellation:
D1 : EP-A-410 045
D1 is also cited page 1 as US-A-5 097 326

D2 : WO-A-82-395
D3 : US-A-5 310 962

The drawings were filed before the date for demand of examination 8 Dec. 1999 and are therefore considered as "original" .

III

Being blind or missing a leg need not be a disease , but a method which makes the invalid person walk again is a therapy .
A leg-prostheses is patentable but the method for mounting it in most european countries is not patentable .
Therefore the method of claims 1 - 21 enabling a blind person to see is a therapy even if the method may not give the blind his full eyesight back ("person" in the first line of claim 1 encompasses blinds , see page 1 line 5 : "enable blind persons to see" or page 1 midst : "enable a blind subject ..." or page 6 second line : "... recognition of complex shapes").
Therefore claims 1 - 21 are not examined due to Rule 67.1.iv PCT

If the sole purpose of the method were to make an image recognition-test with normal-seeing persons being blind-folded , then the method would fall under Rule 67.1.iii PCT (methods of ... playing games) .
Surely no technical problem is solved (Rule 5.1.a.iii PCT) by playing music for a normal-seeing person to make him recognize a picture which he might as well see with his own eyes.
Instead of a method , an encoder may be defined by the manner it encodes.

V

Independent claim 23 is unclear for two reasons , Article 6 PCT :
Only two types of patent claims exist :
- claims for a physical entity (product , apparatus)
- claims for an activity (method , use)
see PCT-Guidelines C-III 3.1
A claim for a physical entity (device) should not contain features of a method.
Therefore the reference in independent claim 23 (for a device) to features from method-claims 1 - 22 is not permissible.
Therefore in claim 23 fourth line:
"... according to any of claims 1 to 22"
is interpreted as :
"... contained within an image" , see claim 1.

In claim 23 last line "the musical sequence" has no reference in the claim.
Probably is meant the musical sequencies in claim 1 , but this again is a mixture of device-features and method-features.
Therefore the last line of claim 23 is interpreted as:
"... playing means (84) for playing musical sequencies corresponding an encoding of the features of the image" .

V .2

In the following claim 23 is interpreted with the above two corrections.
D1 discloses all features of claim 1 :

- a device for enabling a person to visualize images
  (D1 page 1 first lines : "... converting visual images into acoustical representations ... for totally blind ... persons")

- imaging means
  (24 in D1 fig 2 is a camera see P.3 L.53)

- encoding means
  (26 is an image-processing unit P.3 L.54 which converts analog image-signals from the camera and sensor 22 , obviously relating to features of an image, into digital signals , ie. the analog-signals are encoded)

- playing means
  (the data-processor 30 generates a digitized waveform which is D-A-converted 32 and outputted as a musical sequence 16 fig 1 see last lines on page 3)

Thus the present application does not satisfy the criterion set forth in Article 33(2) PCT because the subject-matter of claim 1 is not new Rule 64 PCT.

V .3

The camera 24 in D1 can be a video camera D1 P.9 L.12 or a CCD-camera P.9 L.13
Therefore claims 24 and 25 are not new.

V .4

Image processor 26 in D1 fig 2 is shown in details in fig 4
P.7 L.30 , which is a microprocessor , not a mainframe see P.4 L.15 :
"... a fast mainframe would have been needed"
Therefore claim 26 is not new

V .5

Head-phones 54 in D1 fig 7 obviously can be replaced by an ear-piece
Therefore claim 27 is not inventive

V .6

The device in D1 is hand-held P.4 L.16 "portable"
Therefore claim 28 is not new

V .7

Reference is also made to **D2** figure 1 and to **D3** figure 5 which also show all features of claim 1 of the invention.

VII

The features of the claims are not provided with **reference signs** placed in parentheses (Rule 6.2(b) PCT).

VII .2

All essential features should be in any independent claim see PCT-Guidelines C-III 4.4
On page 1 midst it is said to be an advantage of the invention that it incorporates a system for feature-extraction , but there is no extraction-machinery in independent claim 23.

VII .3

Contrary to the requirements of Rule 5.1(a)(ii) PCT, the relevant background art disclosed in the documents **D1** **D2** and **D3**
is not mentioned in the description, nor are these documents identified therein.

*

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

PCT

To:
MCNEIGHT, David Leslie
McNEIGHT & LAWRENCE
Regent House
Heaton Lane
Stockport, Cheshire SK4 1BS
GRANDE BRETAGNE

NOTIFICATION OF RECEIPT OF DEMAND BY COMPETENT INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

(PCT Rules 59.3(e) and 61.1(b), first sentence and Administrative Instructions, Section 601(a))

Date of mailing *(day/month/year)*: 28.12.99

Applicant's or agent's file reference: M98/0209/PCT

IMPORTANT NOTIFICATION

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/GB 99/01506	12/05/1999	12/05/1998

Applicant: UNIVERSITY OF MANCHESTER INST....TECHNOLOGYetal.

1. The applicant is hereby **notified** that this International Preliminary Examining Authority considers the following date as the date of receipt of the demand for international preliminary examination of the international application:

08/12/1999

2. This date of receipt is:

- [x] the actual date of receipt of the demand by this Authority (Rule 61.1(b)).
- [ ] the actual date of receipt of the demand on behalf of this Authority (Rule 59.3(e)).
- [ ] the date on which this Authority has, in response to the invitation to correct defects in the demand (Form PCT/IPEA/404), received the required corrections.

3. [ ] **ATTENTION:** That date of receipt is **AFTER** the expiration of 19 months from the priority date. Consequently, the election(s) made in the demand does (do) not have the effect of postponing the entry into the national phase until 30 months from the priority date (or later in some Offices) (Article 39(1)). Therefore, the acts for entry into the national phase must be performed within 20 months from the priority date (or later in some Offices) (Article 22). For details, see the *PCT Applicant's Guide*, Volume II.

[ ] *(If applicable)* This notification confirms the information given by telephone, facsimile transmission or in person on: _____

4. Only where paragraph 3 applies, a copy of this notification has been sent to the International Bureau.

Name and mailing address of the IPEA/

European Patent Office
D-80298 Munich
Tel. (+49-89) 2399-0, Tx: 523656 epmu d
Fax: (+49-89) 2399-4465

Authorized officer

SCHWARZKOPF G B

Tel. (+49-89) 2399-8553

Form PCT/IPEA/402 (July 1998) P20452 (22/12/1999)

Submission to Enter National Phase Under 35 US 371

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION CONCERNING SUBMISSION OR TRANSMITTAL OF PRIORITY DOCUMENT

(PCT Administrative Instructions, Section 411)

To:

MCNEIGHT, David, Leslie
McNeight & Lawrence
Regent House
Heaton Lane
Stockport
Cheshire SK4 1BS
ROYAUME-UNI

Date of mailing (day/month/year) 05 July 1999 (05.07.99)	
Applicant's or agent's file reference M98/0209/PCT	**IMPORTANT NOTIFICATION**
International application No. PCT/GB99/01506	International filing date (day/month/year) 12 May 1999 (12.05.99)
International publication date (day/month/year) Not yet published	Priority date (day/month/year) 12 May 1998 (12.05.98)
Applicant UNIVERSITY OF MANCHESTER INSTITUTE OF SCIENCE AND TECHNOLOGY et al	

1. The applicant is hereby notified of the date of receipt (except where the letters "NR" appear in the right-hand column) by the International Bureau of the priority document(s) relating to the earlier application(s) indicated below. Unless otherwise indicated by an asterisk appearing next to a date of receipt, or by the letters "NR", in the right-hand column, the priority document concerned was submitted or transmitted to the International Bureau in compliance with Rule 17.1(a) or (b).

2. This updates and replaces any previously issued notification concerning submission or transmittal of priority documents.

3. An **asterisk(*)** appearing next to a date of receipt, in the right-hand column, denotes a priority document submitted or transmitted to the International Bureau but not in compliance with Rule 17.1(a) or (b). In such a case, **the attention of the applicant is directed** to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

4. The **letters "NR"** appearing in the right-hand column denote a priority document which was not received by the International Bureau or which the applicant did not request the receiving Office to prepare and transmit to the International Bureau, as provided by Rule 17.1(a) or (b), respectively. In such a case, **the attention of the applicant is directed** to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

Priority date	Priority application No.	Country or regional Office or PCT receiving Office	Date of receipt of priority document
12 May 1998 (12.05.98)	9809986.4	GB	25 June 1999 (25.06.99)

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. (41-22) 740.14.35

Authorized officer

Carlos Naranjo

Telephone No. (41-22) 338.83.38

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

INFORMATION CONCERNING ELECTED OFFICES NOTIFIED OF THEIR ELECTION

(PCT Rule 61.3)

To:

MCNEIGHT, David, Leslie
McNeight & Lawrence
Regent House
Heaton Lane
Stockport
Cheshire SK4 1BS
ROYAUME-UNI

Date of mailing (day/month/year)	
14 January 2000 (14.01.00)	
Applicant's or agent's file reference M98/0209/PCT	**IMPORTANT INFORMATION**

International application No.	International filing date (day/month/year)	Priority date (day/month/year)
PCT/GB99/01506	12 May 1999 (12.05.99)	12 May 1998 (12.05.98)

Applicant
UNIVERSITY OF MANCHESTER INSTITUTE OF SCIENCE AND TECHNOLOGY et al

1. The applicant is hereby informed that the International Bureau has, according to Article 31(7), notified each of the following Offices of its election:

   AP :GH,GM,KE,LS,MW,SD,SL,SZ,UG,ZW
   EP :AT,BE,CH,CY,DE,DK,ES,FI,FR,GB,GR,IE,IT,LU,MC,NL,PT,SE
   National :AU,BG,BR,CA,CN,CZ,DE,IL,JP,KP,KR,MN,NO,NZ,PL,RO,RU,SE,SK,US

2. The following Offices have waived the requirement for the notification of their election; the notification will be sent to them by the International Bureau only upon their request:

   EA :AM,AZ,BY,KG,KZ,MD,RU,TJ,TM
   OA :BF,BJ,CF,CG,CI,CM,GA,GN,GW,ML,MR,NE,SN,TD,TG
   National :AE,AL,AM,AT,AZ,BA,BB,BY,CH,CU,DK,EE,ES,FI,GB,GD,GE,GH,GM,HR,HU,
   ID,IN,IS,KE,KG,KZ,LC,LK,LR,LS,LT,LU,LV,MD,MG,MK,MW,MX,PT,SD,SG,SI,SL,TJ,
   TM,TR,TT,UA,UG,UZ,VN,YU,ZA,ZW

3. The applicant is reminded that he must enter the "national phase" **before the expiration of 30 months from the priority date** before each of the Offices listed above. This must be done by paying the national fee(s) and furnishing , if prescribed, a translation of the international application (Article 39(1)(a)), as well as, where applicable, by furnishing a translation of any annexes of the international preliminary examination report (Article 36(3)(b) and Rule 74.1).

   Some offices have fixed time limits expiring later than the above-mentioned time limit. For detailed information about the applicable time limits and the acts to be performed upon entry into the national phase before a particular Office, see Volume II of the PCT Applicant's Guide.

   The entry into the European regional phase is postponed **until 31 months from the priority date** for all States designated for the purposes of obtaining a European patent.

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. (41-22) 740.14.35

Authorized officer:
Olivia RANAIVOJAONA

Telephone No. (41-22) 338.83.38

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

MCNEIGHT, David Leslie
McNeight & Lawrence
Regent House
Heaton Lane
Stockport
Cheshire SK4 1BS
GRANDE BRETAGNE

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Rule 71.1)

Date of mailing *(day/month/year)*	08.09.2000
Applicant's or agent's file reference M98/0209/PCT	**IMPORTANT NOTIFICATION**

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/GB99/01506	12/05/1999	12/05/1998

Applicant
UNIVERSITY OF MANCHESTER INST....TECHNOLOGYetal.

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. **REMINDER**

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/	Authorized officer
European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Ertl, L Tel.+49 89 2399-7447

Submission to Enter National Phase Under 35 US 371

Form PCT/IPEA/416 (July 1992)

In re U.S. National §371 application of: UNIVERSITY OF MANCHESTER
INSTITUTE OF SCIENCE AND TECHNOLOGY

Inventors: John Ronald CRONLY-DILLON and Krishna Chandra PERSAUD

For: VISUALISING IMAGES

**THIS APPLICATION CLAIMS PRIORITY FROM
PCT/GB99/01506, FILED 12 MAY 1999
AND
BRITISH APPLN. NO. 9809986.4, FILED 12 MAY 1998**

Our Docket No. 3547 P 002 (M98/0209/US)

ENCLOSED: POSTCARD

CHECK IN THE AMOUNT OF $502

2-PAGE TRANSMITTAL LETTER TO U.S. DESIGNATED/ELECTED OFFICE CONCERNING FILING UNDER 35 USC §371

3-PAGE PRELIMINARY AMENDMENT

2-PAGE FACSIMILE-EXECUTED VERIFIED STATEMENT FOR NONPROFIT ORGANIZATION

30-PAGE PATENT APPLICATION (INCLUDING 28 CLAIMS)

9 SHEETS OF INFORMAL DRAWINGS (FIGURES 1-11)

2-PAGE FACSIMILE-EXECUTED DECLARATION FOR PATENT APPLICATION (SIGNED BY INVENTORS)

1-PAGE FACSIMILE-EXECUTED POWER OF ATTORNEY (SIGNED BY OFFICER OF MANCHESTER UNIVERSITY)

I HEREBY CERTIFY THAT THIS PAPER AND THE ABOVE DOCUMENTS ARE BEING DEPOSITED WITH THE U.S. POSTAL SERVICE AS EXPRESS MAIL, POSTAGE PREPAID, IN AN ENVELOPE ADDRESSED TO BOX PCT (US NATIONAL APPLICATION/WITH FEE), COMMISSIONER FOR PATENTS, WASHINGTON, DC 20231, ON November 10, 2000 UNDER EXPRESS MAIL NO. EL590261513US.

Susan M Franklin

PLEASE ADDRESS ALL FUTURE COMMUNICATIONS TO:

MONIQUE A. MORNEAULT, ESQ.
WALLENSTEIN & WAGNER
311 South Wacker Drive - 5300
Chicago, IL 60606
(312) 554-3300

110004

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	FOR FURTHER ACTION	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.
M98/0209/PCT		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/GB 99/01506	12/05/1999	12/05/1998

Applicant

UNIVERSITY OF MANCHESTER INST....TECHNOLOGYetal.

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 4 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the **language,** the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

   [ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

   b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

   [ ] contained in the international application in written form.

   [ ] filed together with the international application in computer readable form.

   [ ] furnished subsequently to this Authority in written form.

   [ ] furnished subsequently to this Authority in computer readble form.

   [ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   [ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [X] **Certain claims were found unsearchable** (See Box I).

3. [ ] **Unity of invention is lacking** (see Box II).

4. With regard to the **title,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. 8

   [ ] as suggested by the applicant.

   [X] because the applicant failed to suggest a figure.

   [ ] because this figure better characterizes the invention.

   [ ] None of the figures.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/GB 99/01506

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 22
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
The matter claimed in claim 22 is not clear. See articles 5 and 6.

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.